A laboratory study of coronal microleakage using four temporary restorative materials

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Abstract

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Aim The aim of this study was to compare the sealing abilities of Fermin and Canseal with the more popular temporary coronal filling materials, Cavit and Caviton.

Methodology Standardized access cavities were prepared in 160 intact human permanent molar teeth. They were divided into five groups consisting of 32 samples. The teeth were restored using one of the temporary filling materials, namely: Fermin, Canseal at two powder to liquid ratios, Caviton and Cavit. Thermal cycling and/or load cycling were applied on the samples. Assessment of microleakage utilized methylene blue dye penetration. Grading of the microleakage pattern was from 1 to 3, with 3 providing the best seal. Results were analyzed using two-way anova and by Fisher's PLSD post hoc test ($P < 0.05$).

Result Microleakage along Fermin, Caviton and Cavit samples did not go beyond Leakage Grade 2. Dye penetration into these materials was noted. This was not observed in the two groups of Canseal tested. However, the two groups of Canseal exhibited total leakage notably after being subjected to thermal cycling. There was a statistically significant difference in the microleakage scores obtained between the materials and conditions tested ($P < 0.0001$).

Conclusion Fermin was found to exhibit the best seal amongst the four materials tested followed by Caviton, and Cavit. Thermal cycling influenced the seal of certain types of temporary filling materials more than load cycling.

Keywords: dye penetration, microleakage, temporary filling material.

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Introduction

The use of temporary restorative materials between appointments is one of the factors that determine the success or failure of root canal treatment. These materials serve to seal the tooth temporarily, preventing the entry of fluids, microorganisms and other debris into the root canal space. In addition, they also prevent the escape into the oral cavity of medicaments placed in the pulp chamber (Webber *et al*. 1978).

A coronal filling material is considered effective when it is able to fulfill certain properties including good sealing of tooth margins, lack of porosity and dimensional changes to hot and cold temperatures, good abrasion and compression resistance, ease of insertion and removal, compatibility with intracanal medicaments and good aesthetic appearance (Deveaux *et al*. 1992). Several studies evaluating the microleakage of temporary restorative materials have been conducted and the technique used most to assess sealability has utilized dye penetration with either thermal cycling or load cycling procedures (Krakow *et al*. 1977, Chohayeb & Bassiouny 1985, Noguera & McDonald 1990, Hosoya 1991, Lee *et al*. 1993, Pai *et al*. 1999). Most of these studies focused on the sealing ability of IRM®, Cavit® and, more recently, Caviton®.

A previous study indicated that, of these materials, Caviton appeared to produce the best seal, followed by Cavit and then IRM (Lee *et al*. 1993). Lee and associates

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noted that the seal provided by Caviton and Cavit could be attributed to their expansion on setting due to their hygroscopic property (Lee *et al*. 1993).

There are other types of temporary coronal filling materials available today. One of these is Fermin (Detax GmbH & Co KG, Germany), a zinc sulphate cement used by many dentists and dental students in countries such as the Philippines, and Canseal (Showa Yakuhin Kako Co, Ltd, Tokyo, Japan), a noneugenol cement marketed in Japan. Unfortunately, studies concerning the ability of these two materials to provide a tight seal in endodontic access cavities are rare.

The purpose of this study was to evaluate the sealing ability of Fermin and Canseal, at two powder to liquid ratios, and to compare them with two popular temporary filling materials, Caviton and Cavit, using a methylene blue dye penetration test.

Materials and methods

The temporary restorative materials used in this study are indicated in Table 1. Fermin is a single paste temporary filling material that is primarily composed of zinc sulphate. Canseal is a noneugenol cement that uses a powder and liquid mixing method. The powder component of Canseal is made up of zinc oxide, rogin and magnesium oxide, whilst its liquid component has fatty acids (isostearic acid, linoleic acid, etc.), orthoethoxy benzoic acid and propylene glycol. The main constituents of Caviton are zinc oxide, Plaster of Paris and vinyl acetate whilst those of Cavit are zinc oxide, calcium sulphate, zinc sulphate, glycol acetate, polyvinyl acetate and triethanolamine.

One hundred and sixty extracted caries-free human maxillary and mandibular molar teeth stored in 10% formalin solution were used. The teeth were cleaned of soft tissue and debris before use, rinsed overnight in running water and then immersed in deionized water for 24 h. Standardized access cavities were prepared in the occlusal surfaces of the teeth with the aid of a template measuring 4 mm × 4 mm. Access was made using a high speed air turbine under water coolant with a no. 4 round bur for initial entry and a diamond fissure bur to extend the preparation to the desired occlusal outline. All teeth were irrigated using SC-3000 Ultrasonic Scaler (J Morita Corporation, Kyoto, Japan) and 5% sodium hypochlorite (Wako Pure Chemical Industries Ltd, Osaka, Japan) to remove remaining smear layer, pulp tissues and other debris inside the chamber. The prepared openings were air dried and cotton pellets were placed on the floor of the pulp chamber. A periodontal probe was used to measure the depth of the opening assuring that it could accommodate at least 4 mm of the temporary filling material (Webber *et al*. 1978).

The teeth were divided randomly into five groups of 32 teeth each, as shown in Table 2. The filling materials, Fermin, Canseal (at two powder to liquid ratios), Caviton and Cavit, were incrementally introduced into the access opening from the bottom up with the use of a plastic

Table 1 Temporary filling materials evaluated

Material	Composition*	Batch no.	Manufacturer
Fermin	Zinc sulphate cement	990201	Detax GmbH & Co KG Ettlingen, Germany
Canseal	Powder (P): zinc oxide, rogin, magnesium oxide Liquid (L): fatty acids, orthoethoxy benzoic acid, propylene glycol	P: 6010UA L: 8012 SA	Showa Yakuhin Kako Co., Ltd. Tokyo, Japan
Caviton	Zinc oxide, Plaster of Paris, vinyl acetate, others	100291	GC Corporation Tokyo, Japan
Cavit	Zinc oxide, calcium sulphate, zinc sulphate, glycol acetate, polyvinyl acetate, polyvinyl chlorite acetate, triethanolamine	259 53052	ESPE Dental AG Seefeld/Oberbay, Germany

*As reported by manufacturer.

Table 2 Experimental groups according to the material used

Group no.	Material used
I	Fermin
II	Canseal (powder to liquid ratio = 0.2 g to 2 drops (0.5 g)
III	Canseal (powder to liquid ratio = 0.4 g to 2 drops (0.5 g)
IV	Caviton
V	Cavit

Table 3 Conditions of testing

Group	Experimental condition
A	Control
B	Manual thermal cyling (dwell time = 30 s, 100 cycles 5 ± 2°C/55 ± 2°C)
C	Load cycling (1.3 kg load for 6 h at a rate of 98 cycles min^{-1})
D	Manual thermal cycling followed by load cycling (as described for groups B and C)

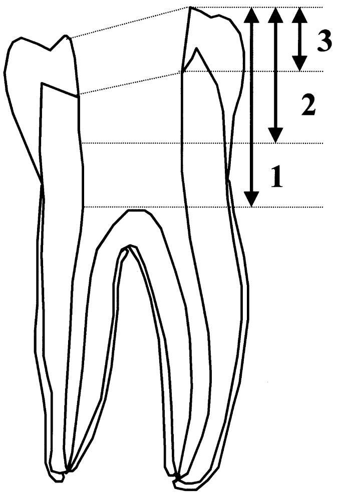


Figure 1 Grades of dye penetration: 1, dye penetration is over half of the pulp chamber; 2, dye penetration is within half of the pulp chamber; 3, dye penetration is within the dentino-enamel junction.

instrument. Every effort was made to ensure that the filling materials were carefully pressed against the cavity walls. The surfaces of filling materials placed in specimens in groups I, IV and V were smoothed with cotton pellet moistened with normal saline (Otsuka Co, Tokyo, Japan) to initiate setting of the materials. The specimens were then placed in normal saline and stored in an incubator (Model IC-450, Iuchi Co., Japan) with the temperature maintained at 37°C for 2 h to ensure setting of the materials (Lee *et al.* 1993).

After setting of the materials, the five experimental groups were divided into four subgroups with eight teeth each to represent the four experimental conditions: group A = control, B = thermal cycling, C = load cycling, and D = thermal and load cycling (Table 3).

All specimens were covered with nail polish (except the access areas) and placed in 2% methylene blue solution and stored in an incubator maintained at a temperature of 37°C for 7 days.

Table 4 Leakage category of filling materials

Condition	No. of specimens	Leakage Grade 3	Leakage Grade 2	Leakage Grade 1
Group I – Fermin				
Control	8	8		
Thermal cycling	8	8		
Load cycling	8	8		
Thermal-load C.	8	8		
Group II – Canseal 1 (P/L ratio of 0.2 g to 2 drops [0.05 g])				
Control	8	7	1	
Thermal cycling	8			8
Load cycling	8	6	2	
Thermal-load C.	8			8
Group III – Canseal 2 (P/L ratio of 0.4 g to 2 drops [0.05 g])				
Control	8	6		2
Thermal cycling	8			8
Load cycling	8	8		
Thermal-load	8			8
Group IV – Caviton				
Control	8	8		
Thermal cycling	8	7	1	
Load cycling	8	7	1	
Thermal-load C.	8	8		
Group V – Cavit				
Control	8	5	3	
Thermal cycling	8	6	2	
Load cycling	8	5	3	
Thermal-load C.	8	4	4	

The specimens were then washed under running water and dried. They were sectioned 3 mm below the cemento-enamel junction before being immersed in cold curing resin (Technovit 4071, Heraeus, Kulzer GmbH, Germany). After polymerization, the specimens were sectioned in a mesiodistal direction along their longitudinal axis with a low speed diamond cutter (Micro Cutter MC-201, Maruto, Japan). The sectioned specimens were viewed and photographed using a stereomicroscope with a camera (Nikon, Tokyo, Japan) at a 2× magnification. The measurement of dye penetration was jointly carried out by the senior author and a coauthor for each specimen at two separate times using a modification of the scoring technique introduced by Lee *et al.* (1993) (Fig. 1). Results were analyzed using two-way ANOVA and by Fisher's PLSD post hoc test ($P < 0.05$) to determine if a statistically significant difference existed between the groups in each of the experimental conditions.

Results

Leakage values differed greatly amongst the materials tested (Table 4, Fig. 2). Amongst the five groups of materials

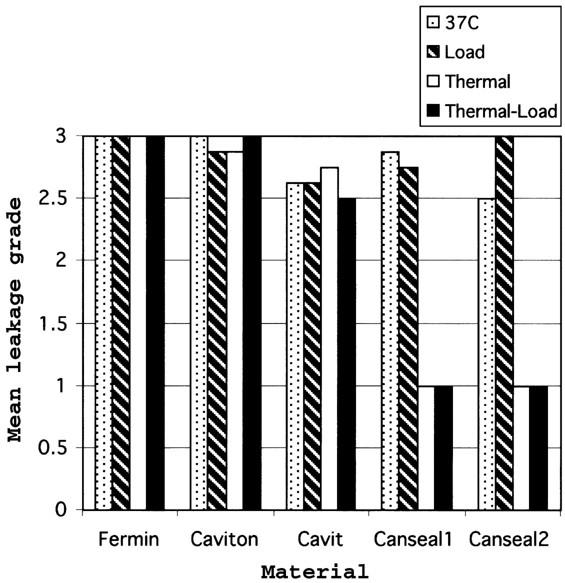
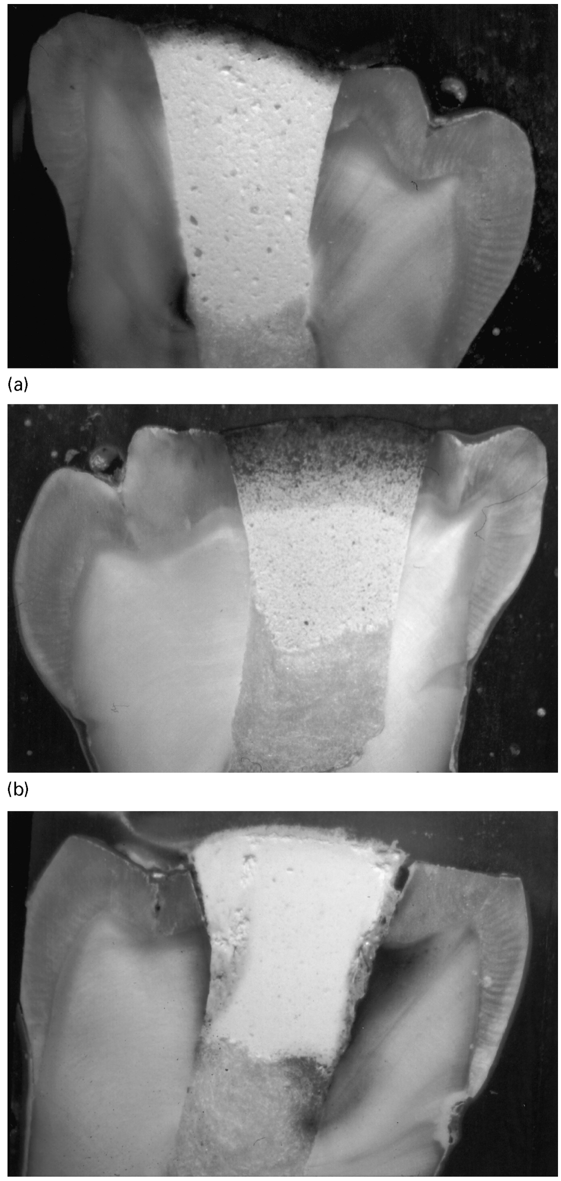


Figure 2 Mean grades of dye penetration of test materials.



(a)

(b)

(c)

Figure 3 (a) Fermin exhibiting grade 3 dye penetration after thermal cycling. (b) Cavit exhibiting grade 2 dye penetration after load cycling. (c) Canseal 1 exhibiting grade 1 dye penetration after thermal cycling.

tested, Fermin showed the least microleakage and a consistent leakage score of 3 in all the experimental conditions. It was followed by Caviton, Cavit and both groups of Canseal. Interestingly, both groups of Canseal presented severe microleakage scores after thermal cycling and thermal-load cycling.

Figure 3 shows the leakage of the test materials under different conditions. Dye penetration into the material was noted in Fermin (Fig. 3a), Caviton and Cavit (Fig. 3b) groups. This was not observed in the two groups of Canseal tested. Canseal in control and load cycling groups presented a nearly perfect seal. However, all Canseal specimens exhibited total leakage notably after being subjected to thermal cycling and thermal-load cycling (Fig. 3c).

No statistically significant difference was noted in the microleakage scores between Canseal 1 (powder to liquid ratio = 0.2 g to 2 drops) and Canseal 2 (powder to liquid ratio = 0.4 g to 2 drops) as well as between Fermin and Caviton (Table 5). Likewise, no significant difference was noted in the scores between load cycling and control groups, and between thermal cycling and thermal-load cycling groups (Table 6).

Discussion

Fermin, Caviton and Cavit are premixed temporary filling materials. This reduces mixing inconsistencies commonly encountered with chairside manipulation of cements. In addition, they set on contact with moisture and possess hygroscopic properties. This enables these materials to provide a tight seal in endodontic access cavities, thereby preventing seepage of bacteria, oral fluids and other debris into the pulp chamber, which is essential for the success of root canal treatment.

A number of methods have been used to evaluate the microleakage of temporary endodontic filling materials

Table 5 Fisher's post hoc values for materials ($P < 0.05$)

	Mean difference	*P*-value
Canseal 1, Canseal 2	0.031	0.7233
Canseal 1, Cavit	–0.719	<0.0001
Canseal 1, Caviton	–1.031	<0.0001
Canseal 1, Fermin	–1.094	<0.0001
Canseal 2, Cavit	–0.750	<0.0001
Canseal 2, Caviton	–1.062	<0.0001
Canseal 2, Fermin	–1.125	<0.0001
Cavit, Caviton	–0.312	<0.0005
Cavit, Fermin	–0.375	<0.0001
Caviton, Fermin	–0.062	0.4791

Table 6 Fisher's post hoc values for conditions ($P < 0.05$)

	Mean difference	*P*-value
Load, control	0.050	0.5266
Load, thermal	0.725	<0.0001
Load, thermal-load	0.750	<0.0001
Control, thermal	0.675	<0.0001
Control, thermal-load	0.700	<0.0001
Thermal, thermal-load	0.025	0.7514

(Noguera & McDonald 1990, Hosoya 1991, Lee *et al.* 1993, Kazemi *et al.* 1994, Mayer & Eickholz 1997, Pai *et al.* 1999). The present study utilized thermal and/or load cycling procedures to simulate intraoral conditions. The temperature range of 55 ± 2°C and 5 ± 2°C that was used in this study corresponds to the extremes of temperatures that could be experienced in the oral environment (Noguera & McDonald 1990). The load applied on the samples in this study was in accordance with the findings of Ishikawa *et al.* (1995), who noted that the load of 1.3 kg seemed to be equivalent to the force exerted when masticating soft food and that the average chewing in humans is approximately 2000 times day^{-1}. Therefore, the load cycle used in this study is roughly equivalent to the total number of times that an individual would chew in a 17-day period. This is within the normal appointment interval of 7–21 days (Messer & Wilson 1996).

The results of this study indicated that maintaining the samples at 37°C (control group) or subjecting them to load cycling procedures (group C) did not produce any significantly increased microleakage. This differs from the findings of Ishikawa *et al.* (1995) after subjecting chemically cured posterior composite restorations to load cycling. These resin materials may take up to 7 days to polymerize and achieve optimum mechanical strength. Therefore, subjecting them to load cycling during the early stage of polymerization could potentially cause microleakage.

In groups where thermal cycling was applied, both groups of Canseal were found to have been severely affected, resulting in gap formation between the filling material and the tooth structure with subsequent leakage of the dye into the entirety of the pulp chamber (Fig. 3c). A similar finding was observed when IRM was tested for its sealing ability (Mayer & Eickholz 1997). This finding could probably be attributed to the instability of zinc oxide when subjected to extremes of temperatures (Windholz *et al.* 1976, Mayer & Eickholz 1997), as well as inconsistencies in the mixing process and the resulting lack of homogeneity (Deveaux *et al.* 1999).

Fermin, Caviton and Cavit, being hygroscopic materials that tend to absorb fluids, exhibited penetration of the dye into the filling material. A similar finding was noted in previous studies (Noguera & McDonald 1990, Lee *et al.* 1993, Pai *et al.* 1999). This was not observed in the case of Canseal. However, the instability demonstrated by Canseal when subjected to thermal cycling raises questions as to its ability to provide a tight seal and this suggests that its use as a temporary endodontic filling material requires re-evaluation.

Dye microleakage and penetration in all Fermin samples did not extend beyond the dentino-enamel junction. Caviton was observed to exhibit better sealing ability as compared with Cavit ($P < 0.0005$) in conformity with the findings of others (Lee *et al.* 1993). However, no statistically significant difference was noted between Fermin and Caviton, suggesting that the quality of seal provided by these two materials is similar.

Conclusion

Amongst the four materials tested, Fermin was observed to provide a consistently tight seal even after being subjected to thermal and load cycling procedures. It was followed by Caviton and then Cavit. This study also showed that thermal cycling procedures seemed to affect the sealing ability of certain types of temporary endodontic filling materials whilst load cycling did not. These results further stress the importance of correctly placing a sufficient thickness of temporary filling material in endodontic access cavities to ensure a tight seal. Additional studies may be needed to verify the quality of seal provided by these materials for prolonged periods.

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